

WHAT IS CLAIMED IS:

1. A diffractive optical element having a design wavelength  $\lambda$ , comprising:

5 a diffractive surface for diffracting predetermined light corresponding to the design wavelength; and

10 a mark shaped so that, with regard to the predetermined light, a phase difference corresponding to a multiple, by an integer, of the design wavelength  $\lambda$  is produced between (i) a light ray, of the predetermined light, as transmitted through or reflected by the mark and (ii) a light ray, of the predetermined light, as transmitted through or reflected by a portion adjacent to the mark, and that, with regard to second light of a second wavelength  $\lambda'$  different from the design wavelength  $\lambda$ , no phase difference corresponding to a multiple, by an integer, of the second wavelength  $\lambda'$  is produced between (a) a light ray, of the second light, as transmitted through or reflected by the mark and (b) a light ray, of the second light, as transmitted through or reflected by a portion adjacent to the mark.

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25 2. A diffractive optical element according to Claim 1, wherein the mark is placed at or adjacent a center of the diffractive surface and is defined by a recess formed on the diffractive surface, and wherein

the recess is formed with a depth effective to assure that a phase difference corresponding to a multiple, by an integer, of the design wavelength  $\lambda$  is produced between (i) a light ray, of the predetermined light, as transmitted through or reflected by the mark and (ii) a light ray, of the predetermined light, as transmitted through or reflected by a portion adjacent to the mark, and that no phase difference corresponding to a multiple, by an integer, of the second wavelength  $\lambda'$  is produced between (a) a light ray, of the second light, as transmitted through or reflected by the mark and (b) a light ray, of the second light, as transmitted through or reflected by a portion adjacent to the mark.

3. A diffractive optical element according to Claim 1, wherein the mark is placed at or adjacent a center of the diffractive surface and is defined by a protrusion formed on the diffractive surface, and wherein the protrusion is formed with a height effective to assure that a phase difference corresponding to a multiple, by an integer, of the design wavelength  $\lambda$  is produced between (i) a light ray, of the predetermined light, as transmitted through or reflected by the mark and (ii) a light ray, of the predetermined light, as transmitted through or reflected by a portion adjacent to the mark, and that

no phase difference corresponding to a multiple, by an integer, of the second wavelength  $\lambda'$  is produced between (a) a light ray, of the second light, as transmitted through or reflected by the mark and (b) a light ray, of the second light, as transmitted through or reflected by a portion adjacent to the mark.

4. A diffractive optical element according to  
Claim 1, wherein the diffractive surface and the mark  
10 are adapted to transmit light rays of the wavelengths  
 $\lambda$  and  $\lambda'$ .

5. A diffractive optical element according to  
Claim 1, wherein the diffractive surface and the mark  
15 are adapted to reflect light rays of the wavelengths  $\lambda$   
and  $\lambda'$ .

6. A diffractive optical element according to  
Claim 1, wherein the diffractive surface comprises a  
20 binary optics, and wherein the diffractive surface and  
the mark are formed in accordance with a lithographic  
process.

7. A diffractive optical element according to  
Claim 1, further comprising a substrate on which the  
25 diffractive surface and the mark are formed, and a  
metal ring for holding the substrate.

8. A diffractive optical element according to  
Claim 1, further comprising a metal ring, wherein the  
mark is placed at a center of the diffractive surface,  
and wherein the mark is disposed at a central position  
of an outside circumference of the metal ring.

9. A diffractive optical element according to  
Claim 8, wherein the mark and the central position of  
the metal ring are registered with each other, on the  
basis of detection of the mark by use of the second  
light of the second wavelength  $\lambda'$ .

10. A projection optical system including a  
15 diffractive optical element as recited in any one of  
Claims 1 - 9.

11. A projection exposure apparatus for  
projecting a pattern onto a substrate by use of a  
projection optical system as recited in Claim 10.

12. A device manufacturing method, comprising the  
steps of:  
exposing a substrate with a device pattern by  
use of an exposure apparatus as recited in Claim 11;  
and  
developing the exposed substrate.